

The Preventative Effects of Fermented Camel Milk Enhanced with Quinoa Seed Paste on Acute Injury in Kidney of Hyperuricemic Rats

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Abstract

The present study investigated the remedial action of fermented camel milk enriched with quinoa seed paste on renal injured hyperuricemic rats. Fermented camel milk was substituted with different proportions of quinoa seed paste while evaluating its acceptability, functionality, and its activity of anti-hyperuricemia in rats. Four different kinds of fermented camel milk (FCM) were prepared with quinoa seed paste (QSP) at ratio (0.0, 10, 20, and 30%). The combined treatment (30%) (FCQP) was found to be the most palatable in terms of sensory evaluation. This blended fermented milk was tested as an anti-hyperuricemia agent in rats. Thirty-two male Wistar rats were assigned into four groups (n=8): the first group was administered the standard diet and served as the negative control, while the second group, were received a basal diet including 20g/kg of potassium oxonate throughout 6 weeks to induce hyperuricemia. The third and fourth groups were administered 10 g/day of FCM and FCQP respectively. The results showed that the hyperuricemic group receiving FCQP was somewhat significantly different from the negative control in the measured biological parameters while achieving significant improvement in the renal function markers compared to the positive control. The biologically favorable action of FCQP could be attributed to its potential promotion of the antioxidant status via enhancing the activities of superoxide dismutase, catalase, and glutathione transferase. The results showed that the renal functions of hyperuricemic rats were enhanced by consuming FCQP. These results demonstrated the ability of FCQP to protect rats from oxidative stress and hyperuricemia. This study concluded that fermented camel milk can be enriched with quinoa seeds milk side to side to improve kidney function as an anti-hyperuricemia agent and mitigate renal damage manifested by decreasing blood urea nitrogen BUN levels.

Keywords: Fermented camel milk; quinoa seeds; liver and kidney markers; blood lipid profile; hyperuricemia; kidney tissues.

1. Introduction

Research on innovative foods and beverages that meet the nutritional requirements of individuals with metabolic disorders, such as obesity, hypertension, diabetes, and dyslipidemia is urgently needed. Hyperuricemia is one among the world's most widespread metabolic illnesses. It may cause some health stuff, including but not limited to gout (Uric acid (UA) crystals accumulate in the bones of the joints and toes.), nephrolithiasis or urolithiasis, or end-stage kidney disease (Kaneko *et al.* 2014), all the previous due to its

increasable effect on the blood uric acid (2,6,8-trihydroxypurine, $C_5H_4N_4O_3$) (**Chen et al. 2009**). The nitrogenous base purines are metabolized to produce UA, which is typically produced by all body cells. Urate levels rise above the commonly accepted thresholds under conditions caused by high purine consumption, endogenous purine metabolism abnormalities, and/or insufficient excretion of uric acid. Consequently, unfluctuating clinical hyperuricemia can provoke gout occurrence. Urinary elimination of UA comprise approximately 60–70% of the whole UA eliminated from the body (**Wang et al. 2008**). It is worth noting that less UA is removed through the gut. (Not the main scope of this review) and further metabolized by resident gut microbiota in a process known as intestinal uric lysis (**Wang et al. 2013**). External sources of purines include foods containing nitrogen compounds, which may promote the buildup of UA in tissues and likely lead to crystal formation. According to **El-Ridi and Tallima (2017)**, these particles have the potential to induce tissue damage as well as significant inflammation, termed articular cartilage ulceration, osteophytes and erosive lesions. In hyperuricemic rats, uricosuric (elevate the urinary elimination of uric acid) and xanthine oxidase inhibitory actions (the enzymes required to produce UA) by the breakdown of purine nucleotides in the liver) may work in conjunction to lower UA levels (**Hameed et al. 2018**). Potassium oxonate induces hyperuricemia by inhibiting the uricase enzyme (urate oxidase) which metabolizes UA into allantoin (the predominant means by which nitrogenous waste is excreted in the urine of animals). Inactivation of the uricase gene in mice results in enormous buildup of UA crystals in the kidney, obstructive nephropathy, and death, with the majority of animals dying before sexual maturity (**Pierzynowska et al. 2017**).

Renal URAT1 levels increased in rats with hyperuricemia brought on by potassium oxonate. (a major urate transporter involved in renal UA reabsorption and excretion) and GLUT9 protein and depressed OTA1 protein levels in comparison to untreated rats. Potassium oxonate administration, inspire that a hyperuricemia model may be successfully established. Elevated serum UA levels may contribute to chronic kidney disease development and progression indicating that in the present study hyperuricemia led to the diminishing of the kidney epithelial brush border furthermore another lesions appearing on histological examination. The overproduction of reactive oxygen species (ROS) causes inflammation, which in turn causes tissue ruin. The functional groups of polyphenol compounds (OH^- groups) found in (FCQP) determine their antioxidant action. Numerous methods of antioxidant activity, including the ability of polyphenols to scavenge a variety of ROS and chelate metal ion, are highly influenced by the number of hydroxyl groups present in a compound (**Hussain et al., 2016**). Camel milk contains immune proteins like lysozyme, an antioxidant and anti-inflammatory, immunoglobulins, and lacks β -lactoglobulin, which can trigger allergic reactions in some people, camel milk possesses a great nutritional and health significance. It also comprises expressive amounts of Fe, K, in addition of vitamins A, E, and C (**Khalesi et al. 2017**). Antioxidant, angiotensin-converting enzyme inhibitory, hypercholesterolemic, antibacterial, diarrhea, and anticancer activities are only a few of the health advantages of fermented camel milk (**Solanki and Hati, 2018**). Owing to the probiotic bacteria found in fermented dairy products, there has been growing emphasis on enhancing them (**Alharbi et al. 2022; Atwaa et al. 2022; El-Zahar et al. 2021**). Plant seeds provide vitamins, dietary fiber, antioxidants, protein, energy, and minerals that are essential to human being health; cereals and their constituent parts are recognized as functional foods. Additionally, cereals can be employed as fermentable materials to help probiotic bacteria flourish (**Al-Anazi et al. 2022; Charalampopoulos et al. 2002**). Plant species called quinoa (*Chenopodium quinoa*) was cultivated 5000 years ago in the Andean region (**Bazile et al. 2016**).

Quinoa is a pseudo-cereal with highly nutrient-dense seed. Due to its lustrous protein concentration, superb amino acids elements contents, and high carbohydrate biomolecules content, considered as a superior plant-based protein origin (**Dakhili et al. 2019**). **Repo-Carrasco-Valencia et al. (2010)**, who evaluated the levels of phenolic acids, flavonoids, and betalains (have anti-inflammatory, liver-protective, anticancer, and antioxidant properties.) in Andean indigenous grains, quinoa (*Chenopodium quinoa*), kañiwa (*Chenopodium pallidicaule*) and kiwicha (*Amaranthus caudatus*). The whole amount of phenolic acids ranged from 16.8 to 59.7 mg/100 g, with soluble phenolic acids ranging from 7% to 61%. Quinoa is a wonderful food for human health because it provides a variety of essential nutrients including unsaturated fatty acids, minerals and vitamins (**Pereira et al.**

2019). Researchers have examined how adding quinoa to food products can enhance their nutritional and sensory qualities (Ujiroghene *et al.* 2019).

Given that there are clues linking certain bioactive substances, for instance phenolic compounds, polysaccharides, and saponins, to a variety of biological activities, including anticancer, anti-inflammatory, and antioxidant activities, the presence of these substances in quinoa suggests their potential beneficial effects (Al-Qabba *et al.* 2020; Cao *et al.* 2020). Owing to its tremendous health benefits, the use of plant-based dairy substitutes has rapidly expanded worldwide. Plant-based dairy substitutes are a great option for patients with chronic conditions because they comprise bioactive components, phenolic compounds, unsaturated fatty acids, and dietary fiber (Sethi *et al.*, 2016). Plant milk substitutes are non-dairy milks that resemble the milk of cows in appearance and are suspensions of cereals that have been dissolved in water. The final non-dairy milk beverages were created by extracting the cereal in water and filtering the liquid phase (Mäkinen *et al.* 2016). The high nutritional content of plant-based milk substitutes, particularly the high quality of proteins, minerals, and polyphenols, makes them a medical or lifestyle choice. Without giving people with celiac disease or lactose intolerance any form of food allergy, diarrhea, or bloating. In addition, it is crucial for patients with hyperuricemia (El-Deeb *et al.* 2014). The current investigations intended to investigate the impact of quinoa seed paste in the fermented camel milk manufacturing process, on its functional properties. In addition, fermented camel milk manufactured from a proportion of quinoa paste was proven for its potential biological effect and capability to use as a functional food treating hyperuricemia artificially induced in rats.

2. Materials and Methods

2.1. Sample Collection

Quinoa seeds were obtained from the Agricultural Research Center, Egypt's Crops Research Institute, Giza, Egypt, and ground to obtain a fine powder. Raw camel milk was obtained from the Desert Research Center of Dokki, Cairo, Egypt.

2.2. Chemicals

Gallic acid, 1,1-diphenyl-2-picrylhydrazyl (DPPH), potassium oxonate $C_4H_2KN_3O_4$ (potassium; 4, 6-dioxo-1H-1, 3,5-triazine-2-carboxylate-IUPAC), other chemicals, and reagents were purchased from Sigma-Aldrich (St. Louis, MO, USA). Kits for the determination of serum albumin, total protein, TG, TC, HDL, GSH-px, GSH-Rd, SOD, urea, and creatinine were purchased from Human, Gesellschaft für Biochemical and Diagnostica mbH, Wiesbaden, Germany.

2.3. Preparation of quinoa seeds paste

With a few adjustments, the recipe for roasted quinoa paste was adapted from Abdelhay *et al.*. The quinoa was manually cleaned and then put in a conventional sand roaster with an iron pan that measured 610 mm in depth and 915 mm in diameter. It was then heated to $280 \pm 5^\circ\text{C}$ for 20 seconds. The roaster was lit by a diesel hob, and the quinoa was constantly swirled to guarantee adequate heating. After that, the quinoa that had been roasted was allowed to cool. Following an 18-hour soak in distilled water, the pre-weighed quinoa was drained, rinsed twice with distilled water, combined with distilled water (1:2) in a flask at room temperature, and then put in a blender to grind into pastes.

2.4. Starter Cultures and Fermented Milk Manufacture

Lyophilized probiotic culture (ABT-5) was obtained from Chr. Hansen (Copenhagen, Denmark), contains a mixed strain of *Lactobacillus acidophilus* La5, *Streptococcus thermophiles* TH4, and *Bifidobacterium bifidum* BB12 at the ratio (1:1:1). Different fermented milk samples were prepared according to the methods described by Tamime and Robinson (1999), with modifications according to El-Zahar *et al.* (2021). Briefly, raw camel milk was enriched with quinoa seed paste at rates of 0.0, 10, 20, and 30%, immediately heated at 90°C for 5 min, and then cooled to 42°C . Then, incubation with 2% activated starter culture (initial counts of $\log 10^7$

CFU/mL for each of the containing bacterial strains) to avoid the quick reduction of pH and transfer into 100 mL plastic containers, lightly sealed, incubated at 42°C until complete curd formation at pH value = 4.6, then stored in a refrigerator ($5 \pm 2^\circ\text{C}$) for 24 h. The physicochemical and sensory properties of the samples were analyzed one day after manufacturing.

2.5. Organoleptic Properties

Sensory studies were conducted on 20 students and lecturers from the Food Science Department, Faculty of Agriculture Medicine, Zagazig University. The panelists were asked to evaluate the color, flavor, acidity, taste, body and texture, and overall acceptability according to the scoring method described by **El-Zahar et al. (2021)**.

2.6. Experimental Design

Thirty-two male Wistar rats (150 ± 10 g) were purchased from the Agricultural Research Center, Giza, Egypt, and alienated randomly into four groups (6 rats/group). Under a 12-h light/dark cycle, the rats were housed in a specific pathogen-free environment at $21 \pm 1^\circ\text{C}$ and 40–60% humidity. Rats were fed a basal diet throughout the experimental period according to the AIN-93 guidelines (**Reeves et al. 1993**). This study was directed with the approval of the National Committee of Bioethics NCBE at King Abdul-Aziz City for Science and Technology, KACST, KSA, Review Board Number: 10024677. The first group served as the normal control (NC). The other rats were switched to a basal diet containing 20 g/kg oxonate (PO-diet) for 6 weeks to induce hyperuricemia and divided into 3 groups (groups 2, 3 and 4). The second group was labelled as a positive control (PC). The third and fourth groups were treated orally with an intestinal tube containing 10 g/day of either FCM or FCQP enriched with 30% QS-paste. Serum samples were taken after the slaughter of rats at the end of the experiment by maintaining the sample at room temperature until blood coagulation, centrifugation at 3000 rpm/10 min and storage at -20°C until analysis

2.7. Chemical Analysis

Chemical analysis was conducted on different fermented milk samples to determine the pH, titratable acidity, ash, protein, fiber, moisture, fat, vitamin C, and mineral content according to the **AOAC (2016)**. The ability of quinoa seed powder to inhibit xanthine oxidase (XO) was evaluated spectrophotometrically at 290 nm in accordance with **Umamaheswari et al. (2007)** and **Sunarni et al. (2017)**, with some adjustments. Xanthine oxidase activity was determined by detecting UV spectrometer-based (UA) production at 295 nm.

The total polyphenolic content of camel milk and quinoa seed paste was measured by the Folin-Ciocalteu assay using a spectrophotometer (Secomam, France) based on the **Škerget et al. (2005)** assay. The total flavonoid content of quinoa seeds was determined using the aluminum chloride colorimetric method described by **Seasotiya et al. (2014)**. Antioxidant activity was evaluated using the DPPH assay (**Anwar et al. 2014**). Scavenging antioxidant activity was determined as follows.

$$\text{AOA (\%)} = (1 - \text{Abs sample} - \text{Abs blank}) / \text{Abs control} \times 100$$

The total cholesterol, HDL, and triglyceride levels in the serum were estimated using the method described by **Anwar et al. (2014)**. Liver enzymes (Superoxide dismutase (SOD), Glutathione peroxidase (GPXs), Glutathione transferase (GST), and Catalase (CAT)), serum albumin, globulin, and total protein were estimated as described by **Ike et al. (2016)**. Urea, uric acid, and creatinine levels were used as indicators of kidney function (**Levey et al., 2015**).

2.8. Statistical analysis

All experiments and related analysis results were performed in triplicate and are presented as mean $\pm$ standard deviation. A variance analysis (two-way ANOVA) with a significance threshold of $p \leq 0.05$ was used to define the differences between groups. Statistica 12.5 software was used to conduct the analysis (Stat Soft Inc., Tulsa, OK, USA) was used to conduct the analysis.

3. Results and Discussion

The current investigation evaluates the indiscriminate action of fermented camel milk enhanced with quinoa seed paste juxtaposes in renally harmed hyperuricemic rats. To achieve this goal, fermented camel milk manufactured by mingled milk (50% camel milk and 50% quinoa seed paste) was evaluated as an antihyperuricemic agent in rats.

3.1. Proximate composition of camel milk (CM) and quinoa seeds milk (QSM)

The results in Table 1, compare the proximate chemical contents of camel milk with those of quinoa seed paste. Compared to CM, QSM contains significantly less fat (1.40%) and somewhat high protein (4.36% vs. 3.76%). The distinctive presence of fibers in the vegetable milk is distinguished from camel milk by its substantially greater levels of whole phenolic (mg GAE/100 g) beside DPPH suppression % activity, i.e., 480.60 and 78.20 compared to 27.14 and 18.10, respectively. These outcomes are agree with those made by **Abdelhay et al. (2026)**, who detected that the total solids, fat, protein, and ash contents of quinoa seeds extract were (22.55, 1.12, 4.66, and 1.60 g/100g), respectively. The faint whole content of phenolic compounds in camel milk as reported by **Shahein et al. (2022)**, who detect a level of 3.62 mg GAE/100 g, whereas the elevated phenol content in QS-paste correspond with the outcomes of **Ranjan and Jacob (2022)**, who reported a level ranging from 24 to 35 mg GAE/ g. Xanthine oxidase (XO) inhibitory activity was 64.50% in quinoa seed paste compared to only 2.30% in camel milk. These findings concur with those of **Cañarejo-Antamba et al. (2021)**, whom evaluated the chemical composition and nutraceutical properties of *Chenopodium quinoa*.

Table 1. Proximate chemical composition, total phenol, %DPPH suppression and xanthine oxidase inhibitory activity % of CM and QSP*

Components (%)	CM	QSP *
Total solids	12.00 ±0.3	23.50 ±0.65
Protein	3.76 ±0.06	4.36 ±0. 08
Fat	3.25 ±0.12	1.40 ±0.02
Ash	0.84 ±0.02	1.76 ±0.03
Fiber	----	3.72 ±0. 01
Total Phenol (mg GAE/100g)	27.14 ±0.4	480.60 ±1.20
% DPPH Inhibition	18.10 ±0.42	78.20 ±3.40
Xanthine oxidase inhibitory activity%	2.30 ±0.20	46.50±3.20

3.2. Chemical composition, physicochemical and photochemical properties of fermented camel milk prepared by camel and quinoa seeds paste

The results showed that Table 2 makes it evident that compared to QS-fermented camel milk, control fermented camel milk recorded proportionally the lowest levels of whole solids (TS), protein, fat, and ash. Otherwise, by increasing the enrichment ratio of QS-paste, the fat and TS contents of fermented camel milk generated from camel milk with a enrichment with QS-paste steadily increased ($p \leq 0.05$), likely as a result of their higher amounts in the original QS-paste. This finding is in agreement with (**Al-Anazi et al. 2022; Ismail et al. 2016; Shahein et al. 2022**), whom found the chemical composition of camel milk changes when it is fortified with soy or watermelon seed milk. Table 2, shows that the control fermented camel milk had the highest acidity level. Titratable acidity was significantly ($p \leq 0.05$) lower when QS-paste was added to camel milk. This decrease in titratable acidity may be caused by the antibacterial action of quinoa seeds (**Medina et al. 2019**), which may

inhibit starter activity and acid generation (El-Deeb *et al.* 2014; Ismail *et al.* 2016). The pH readings of all treatments behaved in a manner opposite to that of acidity, supporting this finding, as they actually measured the level of basicity. The same outcomes were attained by Shahein *et al.* (2022), whom display that the partial replacement of camel milk with rice or watermelon seed milk reduced the TA rate of the formed fermented camel milk. The whole phenolic content (TPC) of fermented camel milk augmented with quinoa seed paste increased significantly ($p \leq 0.05$) with an increase in the enrichment ratio compared to that of control fermented camel milk (Table 3). The TPC of the fermented camel milk produced from camel milk enriched with 10, 20, and 30% QS- paste were 60.8, 95.7, and 122.4 mg/100 g compared to control fermented camel milk with 24.6 mg/100 g. The increasable whole phenolic content of quinoa seeds is the cause of these comparatively elevated TPC values. (Ng *et al.* 2021; Pathan and Siddiqui 2022). Consequently, the radical scavenging activity (RSA) for the fermented milk showed 5, 6, and 7 fold stronger than that of the fermented camel milk when the enrichments level was 10, 20, and 30%. These outcomes are commensurate with those mentioned by (Al-Anazi *et al.* 2022; Shahein *et al.* 2022), who found that adding oats, quinoa and pumpkin seed increased the overall phenolic content and radical-scavenging capacity of fermented camel milk.

Table 2. Chemical composition of fermented camel milk enriched with various ratios of QS-paste during the first storage day

Constituent (%)	Fermented milk types			
	C	T ₁	T ₂	T ₃
Total solids	13.36±0.22 ^d	14.40±0.33 ^c	15.28±0.26 ^b	16.32±0.60 ^a
Protein	4.02±0.64 ^d	4.40±0.18 ^c	4.78±0.42 ^b	5.06±0.54 ^a
Fat	3.42±0.50 ^b	3.55±0.48 ^b	3.70±0.34 ^{ab}	3.85±0.22 ^a
Ash	0.88±0.06 ^d	1.05±0.04 ^c	1.22±0.08 ^b	1.33±0.06 ^a
Fiber	0.0±0.00 ^d	0.35±0.03 ^c	0.68±0.02 ^b	1.02±0.04 ^a
Titrateable acidity %	0.80±0.03 ^a	0.76±0.02 ^{ab}	0.70±0.03 ^{bc}	0.65±0.04 ^c
pH value	4.70±0.01 ^c	4.76±0.02 ^{bc}	4.80±0.03 ^{ab}	4.85±0.02 ^a
TPC (mg /100 g)	24.60±2. 6 ^d	60.80±4.9 ^c	95.70±6.3 ^b	122.40±7.4 ^a
RSA %	7.90±0.4 ^d	40.50±2.6 ^c	52.50±2.7 ^b	56.90±3.2 ^a

Means in the same row that are denoted by several little letters differ significantly ($p \leq 0.05$). The following triplicate analysis of each fermented camel milk experiment was carried out. C: a control, camel milk that has been fermented, T₁: Fermented camel milk enrichment with 10% quinoa seed paste, T₂: Fermented camel milk enrichment with 20% quinoa seed paste, T₃: Fermented camel milk enrichment with 30% quinoa seed paste.

3.3. Sensory properties of fermented camel milk enrichment with quinoa seed paste

The data provided in Table 3 shows that enrichment of camel milk with QS-paste significantly ($p \leq 0.05$) enhanced the sensory qualities of the resulting fermented camel milk, especially its flavor, body, and texture compared to the control fermented camel milk, and this enhancement reflected the enrichment ratio. However, all treatments provided acceptable sensory results. These findings correspond with what was reported by Abdel-Rauf *et al.* (2025), who found that the sensory qualities of fermented camel milk were dramatically enhanced when camel milk enrichment with chickpea milk. By increasing consumers' awareness of health and nutrition issues, the consumer may modify his consumption habits so that they are focused on nutritional and health knowledge instead of solely sensory aspects. Therefore, if the new varieties of fermented camel milk offer

outstanding nutritional and health benefits, they can gradually persuade consumers to change his eating habits. The information presented in this study support this trend.

Table 3. Sensory properties of fermented camel milk enriched with various ratios of QS-paste during the first storage day

Attributes	Fermented milk types			
	C	T ₁	T ₂	T ₃
Appearance	6.50 ±0.58 ^a	6.24 ±0.55 ^{ab}	6.05 ±0.71 ^b	5.92 ±0.77 ^c
Colour	6.14 ±0.2 ^b	6.30±0.4 ^{ab}	6.50 ±0.5 ^a	5.90 ±0.2 ^b
Texture	5.82 ±0.25 ^d	6.10 ±0.30 ^c	6.30 ±0.22 ^b	6.80 ±0.34 ^a
Flavour	5.90 ±0.30 ^d	6.00 ±0.22 ^c	6.32 ±0.14 ^b	6.54 ±0.18 ^a
Mouth feel	4.98 ±0.26 ^c	5.42 ±0.12 ^b	5.96 ±0.32 ^{ab}	6.30 ±0.28 ^a
Overall acceptability	4.88±0.32 ^d	5.60±0.26 ^C	5.92±0.22 ^b	6.24±0.25 ^a

Means in the same row that are denoted by several little letters differ significantly ($p \leq 0.05$). The following triplicate analysis of each fermented camel milk experiment was carried out. C: a control, camel milk that has been fermented, T₁: Fermented camel milk enrichment with 10% quinoa seed paste, T₂: Fermented camel milk enrichment with 20% quinoa seed paste, T₃: Fermented camel milk enrichment with 30% quinoa seed paste.

3.4. Effect of quinoa seed paste-enriched fermented camel on renal function and liver markers

Table 4, showed the effects of administering hyperuricemic rats fermented camel milk prepared using camel milk enriched with QS-paste on the rates of urea, creatinine, uric acid, total protein (TP), albumin, and globulin. Compared to the normal rat group (NC) and other treated groups, the hyperuricemic control group (PC) displayed considerably ($p \leq 0.05$) increased urea, creatinine, and uric acid levels. The negative control's measurements of urea, blood urea nitrogen, uric acid, and creatinine yielded the lowest mean levels (33.9, 15.83, 3.76 and 0.82 mg/L, respectively), whereas the positive control recorded the highest levels (66.8, 31.2, 8.74 and 1.92 mg/L, respectively). When compared to the hyperuricemic rats group, the other group that received QS-paste or fermented camel milk showed significantly decreased indicators of renal function. Compared with normal control group, hyperuricemic rats had considerably ($p \leq 0.05$) lower levels of total serum protein (TP), albumin, and globulin. These serum protein levels increased significantly ($p \leq 0.05$) when hyperuricemic mice were supplied with both fermented camel milk and fermented camel milk with QS-paste, bringing them closer to the normal rate levels. The group receiving fermented camel milk enhanced with quinoa seed paste showed the most improvement, which differed from normal rats (NC) only marginally ($p \leq 0.05$). This startling transformation could possibly be partially related to the quinoa seeds' high concentration of bioactive substances, such as minerals, vitamins, flavonoids, and phenolic compounds above-mentioned (**Dakhili et al. 2019**). These compounds may indirectly lower UA levels and protect kidney from potential oxidative stress damage. Reactive oxygen species (ROS) and UA production are suppressed by the superoxide scavenger effects of these bioactive components (**Das and Roychoudhuty 2014**). In rats with potassium oxonate-induced hyperuricemia, quinoa seed paste may have anti-hyperuricemic effects. The underlying mechanism of quinoa seed paste may be through decreasing xanthine oxidase activity and uricosuric activity, thereby improving UA excretion in the urine (**Li et al. 2021**). Natural antioxidants can lower UA levels in the blood by increasing glomerular filtration rate or direct uricosuric potential. Additionally, a strong antioxidant can reduce oxidative stress and inflammation in body cells, which in turn lowers UA synthesis and overall blood levels (**Kensarah and Azzeh 2012**). Another likely mechanism is that any substance can lower blood UA levels by preventing the xanthine oxidase enzyme from increasing UA synthesis; about 20 times more than camel milk, QS-paste showed an inhibitory effect on xanthine oxidase activity (Table 1). Quinoa seeds contain significant amounts of bioactive substances, including polyphenols that have been demonstrated to have strong xanthine oxidase

inhibitory activity, are likely the cause of this noteworthy activity (**Chen *et al.* 2022**). One may be able to prevent chronic kidney disease (CKD) by switching to QS-paste instead of animal milk (**Alvirdizadeh *et al.* 2020**). **Chiu *et al.* (2020)**, showed that the cumulative effects of plant-based diet on blood UA levels, vegetarians have lower mean UA serum concentrations than non-vegetarians did. The consumption of animal protein which is considered a high source of purines is significantly linked to an increased threat of CKD. Therefore, partially replacing red meat by plant proteins may reduce the prevalence of CKD. Increased plant protein consumption minimizes the threat of acquiring CKD by 16%, demonstrating a robust link between a higher plant protein diet and a reduced probability of widespread CKD (**Yuzbashian *et al.* 2015**). Purine-rich diets with a meat origin are more strongly associated with an elevated threat of gout than plant proteins (**Aihemaitijiang *et al.* 202**). The present data are consistent with those previous reports (**An *et al.* 2021**; **Al-Anazi *et al.* 2022**), who reported that quinoa seeds are antihyperuricemic agents.

Table 4. Urea, creatinine, uric acid, total protein (TP), albumin, and globulin in hyperuricemia rats receiving fermented camel milk enriched with quinoa seed paste

Parameters mg/dL	Experimental Groups			
	NC	PC	FCM	FCQP
Urea	33.90±2.12 ^D	66.80±4.46 ^A	45.74±3.62 ^B	33.44±2.14 ^C
Uric acid	3.76±0.22 ^B	8.74±0.98 ^A	6.30±0.60 ^A	4.02±0.45 ^B
Creatinine	0.82±0.03 ^D	1.92±0.06 ^A	0.98±0.05 ^B	0.86±0.02 ^C
Total protein	8.14±0.65 ^A	4.90±0.26 ^D	6.48±0.82 ^C	7.85±0.90 ^B
Albumin	4.16±0.28 ^B	3.12±0.18 ^D	3.84±0.20 ^C	3.98±0.14 ^{8A}
Globulin	4.85±0.33 ^A	2.90±0.26 ^D	3.92±0.18 ^C	4.35±0.30 ^B

Means in the same row that are denoted by several little letters differ significantly (p 0.05). The following triplicate analysis of each fermented camel milk experiment was carried out. (NC) Non treated non hyperuricemic rats (negative control), (PC) hyperuricemic rats (positive control), (FCM) hyperuricemic rats given a treatment of fermented camel milk and (FCQP) hyperuricemic rats given a treatment of fermented camel milk enhanced with 30% quinoa seed paste.

3.5. Impact of fermented camel milk including quinoa seed paste on the serum lipid profile of hyperuricemic rats

Table 5, shows that total cholesterol rates were reduced in hyperuricemic rats fed fermented camel milk supplemented with QS- paste (77.50 mg/dL) than the positive control (92.2 mg/dL). Additionally, compared to hyperuricemic rats administered FCM and FCQP, which demonstrated a marked reduction in the triacylglyceride and LDL levels (92.4 & 87.90, and 32.02 & 22.32 mg/dL, respectively), the group acting as the positive control included high triacylglycerides and LDL levels (101.70 and 43.27 mg/dL, respectively). Comparing the positive control group to the normal and hyperuricemia groups, the positive control group's HDL content (32.8 mg/dL) was lower. In this context, rats given QS-paste in addition to fermented camel's milk had a statistically significant (p0.05) rise in HDL levels. (37.60 mg/dL). contrasting the hyperuricemia groups given camel milk that has been fermented and those given camel milk that has been supplemented with QS-paste with the group serving as the positive control, the serum triacylglyceride, cholesterol, and LDL levels in the positive control group significantly increased (p≤ 0.05), while HDL levels decreased. The antihyperlipidemic effects of QS-paste may be attributed to its high nutrients content, including minerals, vitamins, polyphenols, and flavonoids, which can bind to lipids and the enzymes that break down lipids to produce emulsification, hydrolysis, and micelle dissolution, which are all followed by absorption (**Al-Anazi *et al.* 2022**). Additionally, the antihyperlipidemic effect may be triggered by free radical scavenging, which halts the cascaded reaction of

lipid oxidation, and by chelating oxidized metal ions, which maintain the activity of HDL-binding paroxonase and prevent LDL oxidation (Kashyap *et al.* 2019). Additionally, high insulin content in camel milk has been shown to activate lipoprotein lipase (Bouhaddaoui *et al.* 2019). Additionally, the high mineral content of camel milk (Na, K, Zn, Cu, and Mg) and ascorbic acid intake may work together to neutralize free radicals (Ashraf *et al.* 2021). Al-Anazi *et al.* (2022) and Shahein *et al.* (2022) discovered the same thing, finding that quinoa seed or fermented camel milk possesses a hypocholesterolemic impact.

Table 5. Serum lipid profile in hyperuricemic rats receiving fermented camel milk containing quinoa seed paste

Parameters mg/dL	Experimental Groups			
	NC	PC	FCM	FCQP
Total Cholesterol (TC)	75.60±5.20 ^A	92.20±4.82 ^D	83.30±3.70 ^C	77.50±3.40 ^B
Triglycerides (TG)	84.20±4.30 ^A	101.70±5.60 ^D	92.40±4.50 ^C	87.90±5.20 ^B
High density-lipoproteins (HDL)	40.30±2.70 ^A	28.50±1.50 ^D	32.80±3.20 ^C	37.60±3.30 ^B
Low density-lipoproteins (LDL)	18.46±1.24 ^A	43.27±2.14 ^D	32.02±2.66 ^C	22.32±2.36 ^B

Means in the same row that are denoted by several little letters differ significantly (p 0.05). The following triplicate analysis of each fermented camel milk experiment was carried out. (NC) Non treated non hyperuricemic rats (negative control), (PC) hyperuricemic rats (positive control), (FCM) hyperuricemic rats given a treatment of fermented camel milk and (FCQP) hyperuricemic rats given a treatment of fermented camel milk enhanced with 30% quinoa seed paste.

3.6. Effect of fermented camel milk enriched with quinoa seed paste on antioxidant enzymatic activity in hyperuricemic rats

Table 6's information demonstrates that the SOD, CAT, GPXs, and GST values of hyperuricemic rats were considerably ($p \leq 0.05$) lower than those of normal rats. However, when compared to the hyperuricemic control, hyperuricemia rat groups treated with fermented camel milk and fermented camel milk containing quinoa seed paste revealed increases in SOD, GPXs, GST, and CAT activities that were substantial ($p \leq 0.05$). Quinoa seeds contain bioactive elements that enhance their biological functions, for instance bioflavonoids, phenols, vitamins, and minerals (Chen *et al.* 2022). Therefore, by achieving a balance between antioxidants and free radicals, Body tissues can be protected against oxidative stress. Caffeic acid is one of the primary antioxidant components of quinoa seeds, and mice treated with fermented camel milk containing quinoa seeds revealed an increase in these enzymes' activity, suggesting their potential to effectively counteract the negative effects of free radicals (Antognoni *et al.* 2021). These results have been confirmed by Al-Anazi *et al.* (2022), who found that fed-induced oxidative stress in rats was treated with red quinoa seed flour, which exhibited increased SOD, GPXs, GST, and CAT.

Table 6. Levels of antioxidant enzymes SOD, GPX, GST and CAT in the kidney of hyperuricemic rats receiving fermented camel milk containing quinoa seed paste

Enzyme activity (u/mg)	Experimental Groups			
	NC	PC	FCM	FCQP
SOD	92.60±4.40 ^A	48.80±3.65 ^D	72.50±5.40 ^C	88.70±5.84 ^B
CAT	5.84±0.36 ^A	1.60±0.08 ^D	3.14±0.32 ^C	5.00±0.20 ^B
GPX	98.20±3.92 ^A	38.35±2.12 ^D	82.54±3.70 ^C	93.86±3.60 ^B

GST	5.22±0.55 ^A	2.66±0.42 ^D	3.98±0.58 ^C	4.82±0.28 ^B
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Means in the same row that are denoted by several little letters differ significantly ($p < 0.05$). The following triplicate analysis of each fermented camel milk experiment was carried out. (NC) Non treated non hyperuricemic rats (negative control), (PC) hyperuricemic rats (positive control), (FCM) hyperuricemic rats given a treatment of fermented camel milk and (FCQP) hyperuricemic rats given a treatment of fermented camel milk enhanced with 30% quinoa seed paste.

4. Conclusion

Based on the information above, quinoa seed paste can be considered an innovative plant-based product offering potential health benefits due to its high content of antioxidants and plant protein. Plant extracts are often used to fortify animal milk in staple products such as fermented milk; in this study, quinoa seed paste was added to camel milk—at levels up to 30%—during the production of fermented camel milk. This addition imparted various health benefits to the fermented product, largely due to its high total phenolic content. The fortification process was found to enhance the product's sensory properties. Furthermore, fermented camel milk containing 30% quinoa seed paste demonstrated excellent efficacy in preventing hyperuricemia in rats; the paste's bioactive components helped prevent this condition by lowering markers associated with renal dysfunction and severe kidney tissue damage. Consequently, the use of quinoa seed paste as an additive (at levels up to 30%) is recommended for the production of functional fermented camel milk.

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